with the granite intrusion above described, though in the present case the greater distance from the granite would make this elevation a less important agent of change.

The specimens which have been described indicate that from ordinary muds and sandy silts, quartz-mica (and in some cases quartz-pyroxene) rocks may be developed by contact metamorphism, and that the differences now to be observed in the mineral composition are due to differences in the original sediments of which the mass was composed. In some cases the rock has become thoroughly crystalline, in others the process is less complete, and a fair quantity of the original dust, possibly in the form of kaolin, still remains. If fragments of larger size have been present, these, though modified like the matrix, can still be recognised. Some of these rocks are no less crystalline than certain of the less coarsely crystalline mica-schists, and occasionally exhibit a foliation. From the latter, however, they can be distinguished by a practised eye. They are fair imitations of some of the indubitably Archæan quartzose mica-schists, but only imitations. Heat has been the main agent of metamorphism in the case of the rocks just described, though probably water was present, and considerable pressure may also have been exercised, which in one case seems to have produced an earlier alteration. Where the original constituents have differed considerably in size, a record of this structure is still retained. Had the elevated temperature been maintained for a longer time, molecular movements among the constituents might have rendered this structure more indistinct, but there is nothing to warrant the supposition that they could have obliterated the distinction between stratulæ of moderate thickness. These specimens then appear to justify us in asserting a sedimentary origin for certain crystalline schists (micaceous, quartzose, &c.), in referring their mineral bands to a stratification of the materials, and in supposing their alteration due to their having been kept at a comparatively high temperature for a considerable period.

III. "On some Variations of *Cardium edule*, apparently correlated to the Conditions of Life." By WILLIAM BATESON, M.A., Fellow of St. John's College, Cambridge, and Balfour Student in the University. Communicated by ADAM SEDGWICK, F.R.S. Received May 13, 1889.

(Abstract.)

In 1886 and 1887 I made a journey to some of the lakes of Western Central Asia for the purpose of making observations on their fauna. As the waters of these lakes are of very various composition, being salt, alkaline, bitter or fresh, in different degrees, I looked forward

to an opportunity of investigating the question whether these diverse environmental conditions produce any correlated changes in the structure of the animals exposed to them. The collections made with this object consist chiefly of Crustacea, of which an account will appear hereafter. The shells forming the subject of the present paper were collected in the district of the Aral Sea and in Egypt.

As is well known, the Aral Sea formerly covered a larger area than it does at the present time. The limits of this area have not been determined, but it has been vaguely suggested that the Aral and Caspian Seas together covered a large part of the steppes of Western Central Asia, probably connecting with the Arctic Ocean, and that the sea thus formed gradually receded until the Aral and Caspian Seas alone remained in their present form. In the course of my journey I visited the valley of the Irghiz and Turgai Rivers and Lake Tschalkar into which they lead; the north and north-west shores of the Aral Sea; the valley of the Shu and Tele Kul Tata into which it leads; also Lake Balkhash, and I nowhere found any direct evidence which could at all support the view that the Aral Sea had gradually receded from a very greatly extended area. On the contrary, all trace of the previous presence of the sea disappeared everywhere abruptly at a level about 15 feet higher than the present level of the Aral Sea. In all places which would be covered if the sea were to rise about 15 feet, shells of the cockle of the Aral Sea (*Cardium edule, var. rusticum*) were found deposited in great quantities, but they always ceased at a definite horizon on ascending. In some places the shore of the Aral Sea is formed of vertical cliffs composed of horizontal beds containing fossils of the age of the London clay of England,* while elsewhere the beach consists of sandy flats extending inland for many miles. Both in the steep places and on the sands the deposits of cockles cease suddenly as described. This seems to be conclusive evidence that the Aral Sea has at all events not *continuously* receded from a very much larger area than that which it at present occupies.

On the north shore of the gulf, Sary Cheganak, a considerable strip of low-lying country has been uncovered. The average width of this shell-covered region is about 3 miles. The post road to Kazalinsk and Tashkend crosses it from north to south. At the post station, Ak Jalpas, is a narrow, dry channel, like the bed of a river. This channel passes up from the Aral Sea, and leads to two large basins which were formerly connected with the sea itself, but which are now dry. The southern basin is called Shumish Kul, and the northern is known as Jaksi Klich. In the course of the channel by which Jaksi Klich was joined to the Aral Sea is a smaller basin,

* These fossils were kindly examined for me by Mr. T. Roberts, of St. John's College, Cambridge, and Mr. Keeping.

Jaman Klich. When the level of the Aral Sea fell, each of these three basins became isolated as a separate salt lake containing a sample of the fauna of the Aral Sea. All three lakes subsequently dried up, and during this process the water must have become salter and salter until only a bed of salt remained.

Shumish Kul is about 8 miles long. The western shore is bounded by high limestone hills, on the foot of which definite terraces are marked by the action of the water as the level of the lake gradually sank during the process of drying up. On these terraces are great numbers of shells of the cockle of the Aral Sea (*Cardium edule, var. rusticum*), being for the most part paired shells with their ligaments preserved, fixed on the oral faces in the crust of oxide of iron and mud, which was formed when the waters of the lake covered them. A series of specimens, therefore, taken from these terraces gives examples of the shells as they were at each stage in the progressive desiccation of the lake, and shows the changes which they underwent as the lake became salter and salter. The principal terraces are seven in number, and the total difference in level between the top and the bottom is about 60 feet.

On comparing the shells found on successive terraces from above downwards, the chief variations noticeable in them are as follows:—

(1.) *Diminution in the Thickness of the Shells.*—This is first apparent in the shells of the third terrace. It proceeds to such an extent that the shells of the lowest terrace are almost horny and semi-transparent. The change in the thickness of the shells is most clearly brought out by the table giving the comparative weights of the shells from different terraces.

(2.) *The Size of the Beak is greatly reduced.*

(3.) *The Shells become highly coloured.*—This change and (1) occur almost uniformly. The shells of each terrace vary very little among themselves in texture, thickness, and colour.

(4.) *The Grooves between the Ribs appear on the inside of the Shell as Ridges with rectangular Faces.*—This change first affects only the ribs behind the 8th and 10th, but on the lowest terraces all the ribs are so affected.

(5.) *On the lowest Terrace the Shells diminished greatly in absolute Size.*

(6.) *The Length of Shells in Proportion to their Breadth increases.*—I use the term "length" to mean the greatest antero-posterior dimension, and the term "breadth" to mean the dorso-ventral measurement at right angles to the length, passing in right valves across the point of the posterior tooth, and in left valves across the depression into which the posterior tooth of the right valve fits. I have found by careful testing that these measurements can be relied on to 0·5 mm.

In the course of these measurements it appeared that—

(*a.*) The change in proportion does not occur in all shells, nor to an equal degree in those in which it is found.

(*b.*) This variation is far more marked in shells of greater absolute size, making it necessary that samples of shells of nearly the same size must be taken for comparison.

(*c.*) This variation occurred slightly in the shells of the 2nd terrace, increasingly in those of the 3rd and 4th, reaching a point in the 5th terrace which is practically not afterwards exceeded, even in shells found as much as 30 feet lower, though the changes in texture, &c., had greatly progressed in these latter. (See tables.)

In this lake shells of *Dreissena polymorpha* were found on the level of the 3rd terrace, and shells of *Hydrobia ulvæ* on most of the terraces, *which did not differ from those of the Aral Sea.*

Jaksi Klich is the largest superficially of the three dry lakes containing cockles. Its length is about 10 miles and its breadth 3 miles. It differs from Shumish Kul in being comparatively shallow, the former having been about 60 feet deep before the separation from the Aral Sea, while the latter cannot have been more than 15—20 feet deep. There is no distinct series of terraces on its banks, but the shells occur in two chief deposits, an upper and a lower deposit. The outer deposit marks the original high level of the water, and the other forms a band of shells round the salt which now fills the bottom of the lake.

Generally speaking, the shells of the lower deposit show the same variations in texture, colour, shape, &c., when compared with those of the upper deposit, as were found in the case of the shells of Shumish Kul. But while the shells of the highest terrace at Shumish Kul were practically the same as those now living in the Aral Sea, those of the upper deposit at Jaksi Klich differ in some particulars, probably in connexion with the fact that Jaksi Klich was always only a shallow lagoon, while Shumish Kul was a deep lake.

The variation in the proportion of length to breadth reaches a greater development in the shells of the inner deposit at Jaksi Klich than in any other shells examined (see tables), excepting those of the fresh water lake, Ramleh, No. 2.

Jaman Klich is a small, independent lake-bed, about half a mile in diameter and about 15—20 feet deep. Its shells show the same variations as those of Jaksi Klich. (See tables.)

On the flats between Shumish Kul and the other two lakes are a considerable number of *very large* shells of *Cardium edule*. These shells have special characters, and perhaps form a distinct variety. Some of them were found at the bottom of Jaksi Klich and Jaman Klich, also in a small dry lagoon, lately separated from the Aral Sea, near Alta Kuduk. As will be hereafter mentioned, similar shells were found deposited in great numbers beneath the surface-soil at

Abu Kir, in Egypt. Shells of this type would appear to be in some manner associated with life in lagoons opening to a sea, as all the localities in which they occurred were of this type. None were found at Shumish Kul or in the Aral Sea itself.

Cardium edule from Lagoons in Egypt.

I collected shells of *C. edule* from the district of Mareotis and Abu Kir in order to compare them with those of the Aral Sea.

Abu Kir has now been pumped dry. In 1888 it was a shallow salt lake, having an area of about 20 square miles. In April, 1888, the specific gravity of the water was 1·05. No living shells were found in it, but its shores were covered with vast quantities of *thin, elongated, highly-coloured shells*, closely resembling those of Jaman Klich. These shells were plainly those which had last lived in the lagoon, and it may be supposed that they lived in it under conditions not greatly different from those now prevailing.

Mareotis.—This is a closed lake lying about 8 feet below the surface of the Mediterranean. At the time of my visit, in April, 1888, the density of the water was about the same as that of the Mediterranean. It is stated to be brackish at high Nile owing to the infiltration of fresh water, though in summer it probably becomes salter than the sea. On its shores I found quantities of shells of *Cardium edule*. There are, apparently, none now living in Mareotis. The absence of living animals may be due to the annual changes which the quality of the water of the lake undergoes, but it is more likely that they have all been exterminated by some of the engineering operations which have at various times been made by different Governments. The shells found on the shore had definite characters. They were elongated shells, moderately thin in texture, having the anterior 6—10 ribs yellowish-white in colour, and the portion 7—12 bluish or chocolate-coloured. The inside of the shells is much ribbed; the posterior part is generally chocolate-coloured, and sometimes this colour extends to the whole interior of the shell. (For particulars of texture and shape, see tables.) The peculiarities in colour and shape of these shells are so great that they could not be mistaken for those of any other locality.

Ramleh Lake No. 1.—By the formation of the Mahmudiyeh Canal (1819) a small piece of water was cut off from Mareotis near Sidi Gaber Station. This lake is about a mile in diameter. Its water is now fresh, and is kept so by the waste water from the irrigations which flows into it. It is about 10—12 feet deep in the middle. Many dead cockle-shells were found in it, but no live ones. These shells have quite definite characters, being very thick and coarse in texture, with 14—16 anterior ribs white, and 3—6 posterior ribs

chocolate colour. The shells are very long in proportion to their breadth. (See tables.)

Ramleh Lakes No. 2 and No. 3.—By the construction of the railway from Alexandria to Cairo another portion of Mareotis has been cut off by an embankment, and the lake thus formed was again divided into two by the second embankment lately made to connect the Cairo Railway with the Ramleh line. In this way two lakes have been formed—an eastern (No. 2) and a western (No. 3). Both these lakes are fresh owing to irrigation-waters. In No. 3 there are no shells of *Cardium* at all, but in No. 2 I found quantities of living specimens. These fresh-water cockles were in texture like the shells found in Ramleh Lake No. 1, but the colour and other features were different. The colour of the outside of the shells is almost uniformly yellowish-white, but on the inside the region of the posterior 3—6 ribs is chocolate colour. The rest of the inside of the shell has the same bright white colour which characterises those of Ramleh Lake No. 1. The proportion of length to breadth in these shells is very great. Another character of these fresh-water shells is the frequent occurrence of specimens with the free ventral margins of the valves bent inwards.

Sub-fossil Shells.—At Mandara and elsewhere I found considerable deposits of very large, thick shells, like those found occasionally at Jaksi Klich in the Aral Sea district. Probably those shells were deposited at the time when Abu Kir and Mareotis formed one or more large lagoons in communication with the open sea.

Recapitulation.

The most important feature of these observations lies in the fact that *the shells of each sample, whether it be from a separate lake or only from a particular level, have special characters, and are more like to each other than to the shells of one of the other lakes or of another level.* The next feature of importance is the fact that in the four independent cases, Shumish Kul, Jaksi Klich, Jaman Klich, and the Egyptian lagoon Abu Kir, *the shells which have lived under similar conditions*, i.e., *in very salt water, resemble each other*, having the characters of thinness, light colour, small beaks, ribbing on the inside of the shell, and great relative length. *Similarly the shells from the two isolated and independent fresh-water lakes at Ramleh also present similar characters, viz., thickness, similar texture, and shape.* It may be remarked that the resemblance between the cockle-shells from an Asiatic lagoon and those from Abu Kir becomes still more striking when it is remembered that their immediate ancestry is very different. For the Asiatic shells had been living for many generations in the brackish waters of the Aral Sea, and had already

become a well-marked variety before being subjected to the new conditions; while those which are found in Abu Kir must clearly be the immediate descendants of animals of the type found in the Mediterranean.

Though the subject cannot be adequately discussed in an abstract, it may be suggested that in so far as any variation (as, for example, that of texture) occurs universally among the shells of a given sample, it may be legitimately supposed that they are correlated to the conditions under which they lived.

Instances in which it is possible to actually trace the history of variation under natural conditions are so rare that these observations of phenomena otherwise unimportant have an increased value. The opportunity given by the terraces of Shumish Kul for the comparison of several distinct stages in the origin of a natural variation appears to be almost unique.

Table showing the Average Ratio of Length to Breadth in Shells from the various Localities.

In each case the average was taken in thirty individuals. It is impossible in an abstract to give the particulars of the measurements; these appear in the fuller account. This table gives a summary of the results. The extremes of length of the shells measured are given in millimetres and the average breadths are given in terms of the length, which is taken as 1.

Locality.	Level.	Smaller samples.		Larger samples.	
		Extremes of length in mm.	Average breadth.	Extremes of length in mm.	Average breadth.
Shore of Aral Sea	..	22—18·5	0·761		
Shumish Kul ...	1st terrace	21—17	0·799		
Ditto	2nd terrace	21—17	0·782	26—19	0·770
Ditto	3rd terrace	22—18	0·751		
Ditto	4th terrace	21—16	0·735	26—18	0·730
Ditto	5th terrace	21—16	0·743	27—21	0·731
Ditto	7th terrace	21—16	0·725		
Jaksi Klich	Upper deposit	22—17	0·740		
Ditto	Lower deposit	25·5—19	0·682	30—25·5	0·660
Jaman Klich....	Lower deposit	24—16	0·726		
Shore of Mareotis	..	..	..	27—20	0·680
Ramleh Lake No. 2	(Fresh water)	21—17	0·665	29—16·5	0·657
Shore of Abu Kir	..	24—19·5	0·738		

Table showing the comparative Weight of Shells of similar Size.

Locality.	Level.	Extremes of length in mm.	Average length of 20 specimens.	Total weight in grams of 20 specimens.
Shore of Aral Sea	..	21—17	19·2	13·3
Shumish Kul	1st terrace	21—17	19·1	14·1
Ditto	2nd terrace	21—17	19·4	14·5
Ditto	4th terrace	21—17	19·2	6·5
Ditto	5th terrace	21—17	18·9	6·1
Ditto	7th terrace	21—17	19·7	4·6
Shore of Abu Kir	..	21—17	19·0	6·4
Jaksi Klich	Upper deposit	23—19	20·4	7·8
Ditto	Lower deposit	23—19	20·4	5·5
Jaman Klich	Lower deposit	21—17	19·2	5·1
Sub-fossil shells at Mandara	..	26—21	23·4	24·2
Shore of Mareotis	..	25—22	23·8	12·0
Ramleh Lake No. 1	(Fresh water)	25—20	21·4	18·3
Ramleh Lake No. 2	(Fresh water)	26—23	24·1	23·6

IV. "On the Occurrence of Skatole in the Vegetable Kingdom." By Wyndham R. Dunstan, M.A., F.C.S., Professor of Chemistry to, and Director of the Research Laboratory of, the Pharmaceutical Society of Great Britain. Communicated by W. T. Thiselton Dyer, C.M.G., M.A., F.R.S. Received May 23, 1889.

Skatole is the name given by Brieger ('Deutsch. Chem. Gesell. Ber.,' vol. 10, p. 1027; 'Journ. für Prakt. Chem.' [2], vol. 17, p. 129) to a substance he obtained in 1887 from human excrement (τὸ σκώρ, σκατός) which possessed the disgusting odour of the fæces. Nencki ('Journ. für Prakt. Chem.' [2], vol. 17, p. 98) soon afterwards recognised the same substance among the products of the decomposition of albumen by fused potash. Secretan ('Deutsch. Chem. Gesell. Ber.,' vol. 10, p. 1031) isolated skatole from the products of the putrefaction of albumen. Later, Salkowski ('Deutsch. Chem. Gesell. Ber.,' vol. 12, p. 651) separated it from the putrefaction products of flesh and afterwards from those of various forms of animal proteid ('Zeits. für Physiol. Chem.,' vol. 8, p. 417). Tappenheimer ('Deutsch. Chem. Gesell. Ber.,' vol. 14, p. 2382) has found skatole in the intestines of several herbivorous animals, and recently Stoehr ('Deutsch. Chem. Gesell. Ber.,' vol. 20, p. 1108) has obtained it, along with indole and other substances, by distilling strychnine